Hanford Site Environmental Monitoring Plan

Section III.C. Meteorological Monitoring

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Introduction

Meteorological monitoring is another aspect of the U.S. Department of Energy's (DOE's) requirements for environmental monitoring and is designed to meet the environmental and meteorological monitoring program objectives stated in DOE Order 5400.1 and described in DOE/EH-0173T. This section identifies the data required to support environmental monitoring activities and to represent other meteorological conditions important to these activities. Also, as an essential element of all environmental monitoring plans, a meteorological information/monitoring program has been developed and is reported on annually (e.g., PNNL-11471).

DOE/EH-0173T details the specific requirements of a meteorological monitoring program and addresses the following considerations:

- meteorological program basis
- meteorological data for dose assessment calculations
- meteorological measurements
- inspection, maintenance, and calibration
- data summarization and archiving
- quality assurance.

This section discusses the composition of the Hanford Site meteorological monitoring program as it relates to DOE Order 5400.1 and DOE/EH-0173T.

Meteorological and Climatological Services Project

The Pacific Northwest National Laboratory (PNNL) Meteorological and Climatological Services Project provides the DOE-Richland Operations Office (RL) and Hanford Site contractors with meteorological and climatological support for emergency response, weather forecasting, climatological data, and related special requests through the operation of the Hanford Meteorology Station (HMS). The project responds to Hanford Site needs through a program that includes the following:

- extensive data acquisition through a sitewide meteorological monitoring network

- site-specific forecasts, using weather satellite imagery and National Weather Service products (through the Automation of Field Operations and Services system)

- standard hourly surface weather observations and 6-h synoptic observations

- climatological data through monthly and annual summaries (e.g., PNNL-11471), meteorological input to annual environmental reports (e.g., PNNL-11472), and responses to ad hoc requests.

Meteorological Monitoring Network

The Hanford Site covers a large area with significant variations in topography and with elevations ranging from approximately 100 to nearly 1,100 m above sea level. To characterize the meteorological conditions on and around the Hanford Site, 30 monitoring stations have been installed onsite and nearby offsite (Table III.C-1 and Figure III.C-1). Station locations were selected to reflect the influence of the varied topography, especially on wind speed and direction, and to provide appropriate data for atmospheric transport and diffusion modeling and for site characterization. The station-selection process was based on an understanding of the effects of synoptic- and meso-scale meteorological events on wind flow over the Hanford Site and also from model studies of atmospheric transport that were run specifically to indicate areas where additional wind data were required. The meteorological monitoring network was designed to perform the following functions:

- to represent implicitly the effect of the varying topography of the Hanford Site on atmospheric circulations by strategic siting of the individual stations
- to monitor and collect real-time meteorological data at locations where operations are conducted that could have a possible negative impact in the event of an emergency
- to provide meteorological data for daily operational forecasting for Hanford Site activities
- to provide real-time meteorological data for atmospheric transport and diffusion modeling
- to provide climatological data for environmental assessments, environmental impact statements, facilities planning, etc.

A 125-m tower, located at the HMS, is instrumented at multiple levels for wind speed and direction and temperature. This tower has been used for collecting data since the mid-1940s. Three 60-m monitoring stations, instrumented at multiple levels, are located in onsite areas where significant operations are conducted. These stations provide additional necessary information as input to atmospheric transport and diffusion models. Twenty-six 10-m towers are instrumented for wind speed and direction (at 10 m) and temperature (at 2 m). Most stations also record precipitation. Detailed descriptions of each meteorological monitoring site, including narrative and photographic depictions of the topography proximate to each, can be found in PNL-6684.

Meteorological Instrumentation

The meteorological instrumentation provides data, including wind speed and direction, temperature, vertical temperature difference, dew-point temperature, and precipitation. Other data are collected via the surface observation program, including sky condition, cloud type and amount, ceiling height, mixing depth, atmospheric pressure, weather and obstructions to visibility, relative humidity, and solar radiation (PNL-6509).

Wind. Wind speed and direction are measured at the 10-m level at all of the remote meteorological monitoring stations, at the 25- and 60-m levels on the three 60-m towers onsite (see Table III.C-1), and at the 2.1-, 15.2-, 30.5-, 61.0-, 91.4-, and 121.9-m levels on the 125-m tower at the HMS.

Wind speed at most monitoring stations (except Stations 19, 20, 22, and 25) (see Figure III.C-1) is measured using sensors (3-cup heavy-duty aluminum anemometer) with a low starting threshold over a

Table III.C-1. Hanford Site Meteorological Monitoring Towers

Site Number	Site Name	Tower Height, m	Instrumentation
1	Prosser Barricade	10	WS, WD, T, P
2	Emergency Operations Center	10	WS, WD, T, P
3	Army Loop Road	10	WD, T, P
4	Rattlesnake Springs	10	WS, WD, T, P
5	Edna	10	WS, WD, T
6	200-East Area	10	WS, WD, T, P, AP
7	200-West Area	10	WS, WD, T, P
8	Beverly	10	WS, WD, T, P
9	Fast Flux Test Facility	60	WS, WD, T, TD, DP, P, AP
10	Yakima Barricade	10	WS, WD, T, P, AP
11	300 Area	60	WS, WD, T, TD, DP, P, AP
12	Wye Barricade	10	WS, WD, T, P
13	100-N Area	60	WS, WD, T, TD, DP, P, AP
14	WNP-2	10	WS, WD, T, P
15	Franklin County	10	WS, WD, T
16	Gable Mountain	10	WS, WD, T
17	Ringold	10	WS, WD, T, P
18	Richland Airport	10	WS, WD, T, AP
19	200-West (Plutonium Finishing Plant)	10	WS, WD, T, AP
20	Rattlesnake Mountain	10	WS, WD, T, P
21	Hanford Meteorology Station	125	WS, WD, T, P, AP
22	Pasco	10	WS, WD, T, P
23	Gable West	10	WS, WD, T
24	100-F Area	10	WS, WD, T, P
25	Vernita Bridge	10	WS, WD, T
26	Benton City	10	WS, WD, T, P
27	Vista	10	WS, WD, T, P
28	Roosevelt	10	WS, WD, T, AP, P
29	K-Basin	10	WS, WD, T, AP, P
30	HAMMER	10	WS, WD, T

AP = atmospheric pressure.
DP = dew-point temperature.
P = precipitation.
T = temperature.
TD = temperature difference.
WD = wind direction.
WS = wind speed.

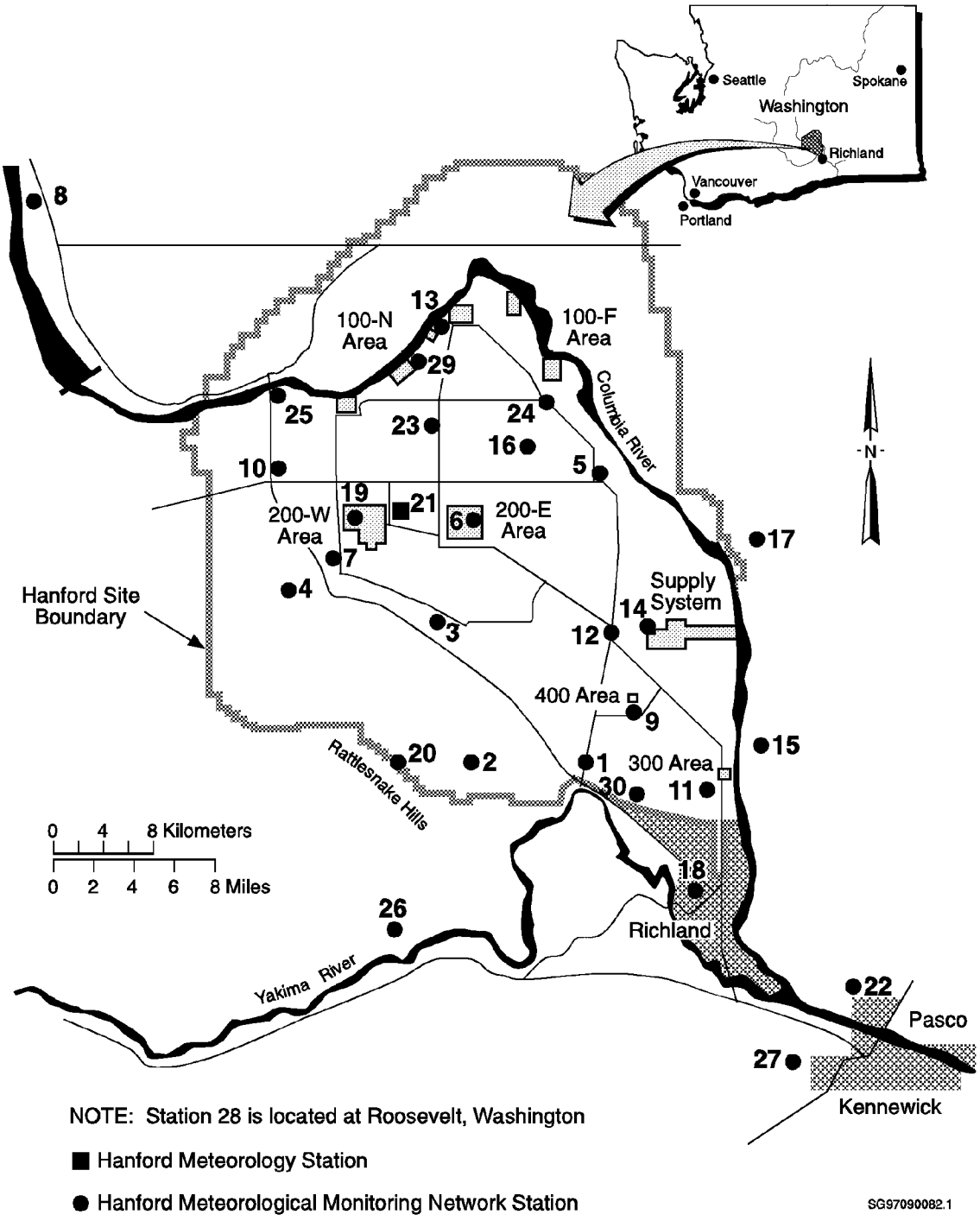

Figure III.C-1. Meteorological Monitoring Stations on the Hanford Site and in Surrounding Areas

wide range of wind speeds. At Station 20, located on the top of Rattlesnake Mountain, where light winds are unusual and sustained wind speeds in excess of 45 m/s are common, a sturdier anemometer (with a higher starting threshold but a greater range) is used. At Stations 19, 22, and 25, which are solar powered, a wind monitor (with a propeller, rather than a cup anemometer) is used because it is less susceptible to freezing (because of moisture and fog). The wind-speed sensor specifications, by station number, are indicated below:

- **Stations 1 to 18, 23, 24, 26 to 30**

Threshold	0.22 m/s
Operating range	0 to 56 m/s
Accuracy	0.07 m/s or 1.0%, whichever is greater

- **Station 19**

Threshold	1.0 m/s
Operating range	0 to 60 m/s (gust survivability to 100 m/s)

- **Station 20**

Threshold	1 to 2 m/s
Operating range	0 to 90 m/s (gust survivability to 90+ m/s)

- **Station 22**

Threshold	1.0 m/s
Operating range	0 to 60 m/s (gust survivability to 100 m/s)

- **Station 25**

Threshold	0.4 m/s
Operating range	0 to 40 m/s (gust survivability to 45 m/s).

Wind-direction sensors at most of the monitoring stations, except Stations 19, 20, 22, and 25 where wind monitors are used, are counterbalanced, lightweight vanes attached to a shaft coupled to a precision low-torque potentiometer. These sensors have low starting thresholds and fast dynamic response. The wind-direction sensor specifications, by station number, are indicated below:

- **Stations 1 to 18, 23, 24, 26 to 30**

Threshold	0.22 m/s
Operating range	0 to 360 degrees
Accuracy	±2 degrees
Damping ratio	0.4 at 10 degrees initial angle of attack
Distance constant	1.1 m

- **Station 19**

Threshold	1.0 m/s
Operating range	0 to 360 degrees
Accuracy	±5 degrees

- **Station 20**

Threshold	1.0 m/s
Operating range	0 to 360 degrees
Accuracy	±5 degrees

- **Station 22**

Threshold	1.0 m/s
Operating range	0 to 360 degrees
Accuracy	±5 degrees

- **Station 25**

Threshold	0.7 m/s
Operating range	0 to 360 degrees
Accuracy	±3 degrees.

The wind-speed and wind-direction sensors at all monitoring locations, except Stations 19, 20, 22, and 25, are heated to minimize the accumulation of rime and/or freezing precipitation during the winter.

Temperature. Air temperature is measured at 1.7 m at all of the monitoring stations, with additional measurements at the 10- and 60-m levels (for measurement of ΔT for atmospheric stability designation) at the three 60-m monitoring stations (see Table III.C-1). Temperature is measured at the 0.9-, 9.1-, 15.2-, 30.5-, 61.0-, 76.2-, 91.4-, and 121.9-m levels on the 125-m tower.

The temperature sensor (on all but the 125-m tower) is an epoxy-coated thermistor composite that exhibits relatively large resistance changes in response to small temperature changes. Fast-response sensors (with a time constant of 0.6 s) are used. All of the 10-m monitoring stations have naturally aspirated radiation shields, and the three 60-m stations have mechanically aspirated shields. The thermistor temperature sensor specifications are given below:

Probe accuracy	±0.15°C
Range	-30.0 to 50.0°C
Time constant	0.6 s.

On the 125-m tower, temperatures are measured using a platinum resistance temperature device contained in a 15-cm-long stainless-steel housing mounted in a mechanically aspirated radiation shield. The platinum resistance temperature sensor specifications are given below:

Probe accuracy	±0.1°C
Range	-50.0 to 100.0°C
Time constant	15 s.

Temperature Differencing. Temperature differencing is one of several methods used to determine atmospheric stability, which is one of the parameters used in transport and diffusion calculations. Atmospheric stability is a measurement of the buoyancy of a parcel of air. The buoyancy of a parcel of air depends on its density relative to the density of the environment at the same level. If a parcel is heavier than its environment, it will tend to sink (stable); if a parcel is lighter than its environment, it will tend to rise (unstable); and if the weight is the same, it will remain at the same level as its environment (neutral). Stability classes can be determined by measuring the difference between air temperatures at two levels.

The ΔT calculation at the 125-m tower is made using the difference between actual temperatures measured at the 61.0- and 9.1-m levels of the tower. At the three 60-m monitoring stations, which measure temperature difference rather than actual temperature between 10 and 60 m, a ΔT translator contains the electronics for converting the variable resistance from the temperature thermistor elements to low-impedance signals, then takes the difference between the two signals and converts this difference into a ΔT. The temperature sensors used are discussed above.

Dew-Point Temperature. Dew-point temperature is measured at the 1.7-m level at the three 60-m towers. The dew-point sensor is housed in a mechanically aspirated temperature/dew-point shield and consists of bifilar gold electrodes wound on a lithium chloride-impregnated glass fiber wick that encloses a thermistor temperature sensor. The dew-point sensor specifications are given below:

Operating range	-40 to +50°C
Relative humidity operating limits	From 100% to the relative humidity at which the lithium chloride salt temperature is 2°C above the ambient temperature (11% to 18% relative humidity).

At the HMS, a hygrothermometer system is used to measure the dew-point temperature. The monitor is located 1.5 m above the ground and uses a chilled-mirror system to monitor the dew point. The specifications for the hygrothermometer are the following:

Operating temperature	-50 to 70°C
Relative humidity	5% to 100%
Ambient temperature	±0.6°C from -50 to 50°C accuracy
Dew-point accuracy	±0.6°C when >0°C.

Precipitation. Precipitation measurements, using recording rain gauges, are made at 22 of the 30 monitoring stations. Each rain gauge has a 20-cm-diameter opening to collect precipitation. Two compartments alternately fill with precipitation and tip (emptying the compartment), causing momentary closure of a mercury switch. The funnels are electrically heated for measuring the water equivalent of frozen precipitation. The heater is thermostatically controlled to be activated when the ambient temperature drops to 4°C. These gauges are sensitive to 0.25 mm and are accurate to 0.5% for a rainfall rate of 12.70 mm/h. The average precipitation event at the HMS is only 2.3 mm.

Atmospheric Pressure. Atmospheric pressure is measured at the 2-m level at the 10 sites indicated in Table III.C-1. The sensors are located within the signal interface unit enclosures. The pressure sensor specifications are given below:

Scaling range	800 to 1,100 mb
Nonlinearity	±0.05% of full scale
Full-scale accuracy	±0.1% of full scale or ±0.3 mb.

Instrument Calibration and Maintenance

All measurement and test equipment is calibrated on an annual basis, and the calibrations are spread throughout the year. The maintenance services calibration recall system is used to notify the project manager when instrument calibration is due. However, because data are reviewed hourly by the forecaster on duty, any apparent problems with data from a particular station are immediately noted and the instrument specialists are advised. Instruments are recalibrated after any repair before being returned to use. Because of the large number of monitoring locations and the distances involved, it is not practical to perform total system calibration on a more frequent basis. Again, because of the large number of monitoring locations that contribute data to the meteorological monitoring system, the temporary loss of data from one or two locations is not critical to the operation of the system as a whole. Even so, every attempt is made to keep the amount of downtime to a minimum.

In accordance with quality assurance requirements, PNNL maintains the procedures for calibration of all measurement and test equipment used by the Meteorological and Climatological Services Project. Primary, secondary, and traveling calibration standards are traceable through the Hanford Standards Laboratory to the National Institute of Standards and Technology. The procedures state that 2 mo before the expiration of calibration on any piece of equipment or instrument, a notice of instrument calibrations is generated that specifies the instrumentation scheduled for calibration. The notice is reviewed and signed by the instrument custodian (in this case the Meteorological and Climatological Services Project manager), authorizing the calibration of the equipment specified. On completion of calibration, a record of calibration is generated, and copies of the record are provided to the applicable instrument laboratory, the instrument custodian, and the PNNL Maintenance Services Department.

Data Acquisition

Data are acquired and processed at each monitoring station using a signal interface unit and a telemetry unit. Most of the signal interface and telemetry units are powered commercially; however, units at three sites (7, 8, and 25) are powered by batteries charged by solar panels. The signal interface unit acquires and processes the signals from the individual instruments, and the telemetry unit transmits the processed data to the HMS via a radio repeater on Rattlesnake Mountain. Inputs to the signal interface unit may be analog, counter, or digital. The unit scans its channels for information every 5 s (or every second for the tipping bucket rain gauge), stores the information for 15 min, and sends the 15-min-averaged values (made up of 180 samples) to the HMS. Values are transmitted on the hour and at 15-min intervals. The output is a digital sequence of numbers transmitted at 416.5 MHZ with 4 W of power.

The data transmitted from the remote monitoring stations are received at a base station located at the HMS and are sent to an International Business Machines (IBM) RISC System/6000 computer via an RS-232 serial data link.

Atmospheric Transport and Diffusion

Because the Hanford Site covers a large area with varying topographic characteristics, a meteorological monitoring system with a network of 29 remote stations and the HMS is used to estimate the meteorological conditions across the complex terrain of the site.

Because of this varying terrain, use of a straight-line Gaussian model is not appropriate; instead, a

trajectory model that treats atmospheric transport and diffusion as separate processes is used. An interactive Lagrangian puff dispersion model, MESOI Version 2.0 (NUREG/CR-3344, PNL-4753), was developed for use at the Hanford Site for estimating the transport and diffusion of effluents released to the atmosphere, and the Mesorad Dose Assessment Model (NUREG/CR-4000, PNL-5219) was developed for emergency response applications. Meteorological data (15-min averaged) are available on a network server that can be accessed by emergency response organizations to import data for their modeling needs.

Quality Assurance

Quality assurance for the Meteorological and Climatological Services Project is established and implemented by PNNL's formal quality assurance program, as contained in PNNL's Standards-Based Management System (PNNL 1997). The quality assurance program conforms to the requirements of DOE Order 5700.6C.

Independent surveillances and audits of the Meteorological and Climatological Services Project activities and procedures to ensure compliance with PNNL's Quality Management System and the project quality assurance plan are conducted by the PNNL Process Quality Department. These surveillances and audits can be initiated by the DOE-RL monitor, the PNNL program manager, the project manager, or the project quality engineer on either a routine and/or a random basis.

Data Management

Meteorological data from the monitoring network are collected, processed, and archived on an IBM RISC System/6000 computer system at the HMS. This system is a "nearly fault-tolerant" system, with dual central processing units and redundant mirrored disks. Incoming data are written to several independent hard disks on separate disk servers simultaneously, so that data are available even in the event of the failure of a disk or disk server. Each central processing unit also has a separate uninterruptible power supply in the event of a power outage. The operating system runs High Availability Clustered Multi-Processing (HACMP™) software to help ensure that no single component or software failure will disable the system.

The Scientific Application, Visualization, and Initialization in Three Dimensions (savi3D™) environmental workbench commercial software is used for data management and display.

The 15-min-averaged data from the monitoring network are used as input to atmospheric transport and diffusion models for emergency response and are maintained for 10 d on the mainframe computer. At the beginning of the 11th day, the first day of the 15-min data is purged and 15-min data from the newly designated 10th day are stored.

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savi3D is a registered trademark of Supercomputer Systems Engineering Services Company (SSESCO), Shoreview, Minnesota.

HACMP is a registered trademark of IBM, Austin, Texas.

For permanent storage, the 15-min data are converted into hourly data. These data are processed daily using the ARCHIVE computer code (PNL-6279, Vol. 10). This computer program converts hourly binary meteorological data from the 10-, 60-, and 125-m towers into formatted (ASCII) data and organizes the converted data into appropriate monthly files.

At the beginning of every month, the monthly data on the IBM RISC System/6000 are processed prior to permanent storage. All data are reviewed using quality assurance computer programs (PNL-6279, Vol. 9). These programs check all data for the following types of potential errors:

- parameters out of range (e.g., January temperature >16.7°C)
- unreasonable changes in parameter magnitude from one hour to the next (e.g., temperature change >5.6°C)
- parameter conflict (e.g., visibility below a specific threshold value with no obstructing phenomena indicated [fog, snow, etc]).

These programs generate error listings that allow for the resolution of possible data irregularities. These computer-generated error listings are maintained on file; however, errors that can be readily resolved are corrected and archived. If they cannot be corrected, the data are indicated as "missing."

On completion of these monthly quality assurance checks, the final data are archived on multiple hard disks, and are available for additional processing (e.g., joint frequency distributions, wind roses, data summaries), as necessary.

Exceptions

No exceptions have been taken to *should** statements in DOE/EH-0173T.

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